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AUTHORITY

ONR ltr, 8 Oct 1975

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BOEING

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SECOND PROGRESS REPORT

For Period Ending 15 June 1973

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VARIABLE CAMBER WING

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Contract No. N00014-73-C-0244

The Boeing Aerospace Co.

June 1973

TABLE OF CONTENTS

1.0 SUMMARY

1. The first series of wind tunnel tests were completed on June 15 and the second series is scheduled to begin on June 25.

2. Preliminary force and moment data indicate that large improvements in performance were achieved relative to the basic F-8.

3. Several alternative leading edge concepts permitting increased deflection have been designed.

4. Approximate weight increments for the boiler plate technology demonstrator prototype have been determined.

2.0 TECHNICAL STATUS

WIND TUNNEL TEST PROGRAM

The initial series of wind tunnel tests which were designed to demonstrate the aerodynamic advantages of an advanced technology variable camber wing have been completed. These tests were conducted during twenty-four shifts of occupancy time at the NASA Ames 14-foot transonic wind tunnel between May 21 and June 15, 1973.

The configurations tested consisted of the basic F-8, the F-8 with an advanced technology wing, the advanced wing with simple hinged leading and trailing edge flaps and various combinations of smooth, curved variable camber flaps. A summary of the test configurations and test conditions is presented in Figure 1.

Examination of preliminary force and moment data indicates that very substantial performance improvements over the basic F-8 were obtained, however, the magnitude of these improvements will not be determined until final data are available from NASA in early July.

The wind tunnel model of the ATVCW was equipped with two streamwise rows of pressure taps at 24% and 64% semispan respectively. Preliminary test results indicate fairly good agreement between theory and experiment for approximately similar conditions.

FIGURE 1 TEST SUMMARY - AMES 14' TRANSONIC WIND TUNNEL

CONFIGURATION	RUN NUMBER	MACH NUMBER	ANGLE OF ATTACK	YAW ANGLE	L.E. DEFLECTION	INBOARD T.E. DEFLECTION	OUTBOARD T.E. DEFLECTION	HORIZONTAL TAIL INCIDENCE
BASIC F-8 (Inverted)	1-5	.7,.9,.925 .95,1.15	-5° to 5°	0	0	0	0	OFF
(Upright)	6-13	.7,.9,.925 .95,1.15	-2° to max.	0	0	0	0	OFF,0°
	14-18	.7,.9,1.15	-2° to max.	5°	0	0	0	0°
ADVANCED TECHNOLOGY WING	21-34,* 99-102*	.7,.9,.925 .95, 1.15	-2° to max.	0	0	0	0	OFF,0° -5°,-10°
	19,20	.7,.9	-2° to max.	5°	0	0	0	0°
ATVCW + SIMPLE HINGED FLAPS	86-91*	.7,.9,1.15	-2° to max.	0	0	-2S	-2S	OFF,0°
	35-37	.7,.9,1.15	"	"	10S	0	0	OFF
	48,49	.7,.9	"	"	20S	0	0	OFF
	38,39*	"	"	"	10S	5S	5S	OFF
	40-43	"	"	"	20S	5S	5S	OFF,-5°
	44-47	"	"	"	20S	10S	10S	OFF,-5°

* PRESSURE DATA OBTAINED

FIGURE 1 TEST SUMMARY - AMES 14' TRANSONIC WIND TUNNEL (Continued)

CONFIGURATION	RUN NUMBER	MACH NUMBER	ANGLE OF ATTACK	YAW ANGLE	L.E. DEFLEC-TION	INBOARD T.E. DEFLEC-TION	OUTBOARD T.E. DEFLEC-TION	HORIZONTAL TAIL INCIDENCE
ATVCW + CONFORMAL FLAPS	53-56, 82*,83*	.7,.9	-2° to max.	0	7.5C,15C 30C	0	0	OFF
	50-52*	.7,.9,1.15	"	"	22.5C	0	0	"
	84,85	.7,.9	"	"	15C	10C	10C	"
	57-60*	"	"	"	30C	5C	5C	OFF,0°
	61-66*	"	"	"	"	10C	10C	OFF,0°,-5°
	67-70	"	"	"	"	18C	18C	OFF,-5°
ATVCW + MIXED CONFORMAL AND SIMPLE HINGED FLAPS	71,72	.7,.9	-2° to max.	0	30C	10S	18C	OFF
	73,74	"	"	"	"	"	10S	"
LATERAL CONTROL	92,93, 94	.7,.9,1.15	-2° to max.	0	0°	Left+5S Right-5S	0	0°
	97,98	.7,.9	"	"	"	Left 0 Right-15S	"	"
	95,96	"	"	"	"	Left+25S Right-15S	"	"
	77,78	"	"	"	30C	Left+10S Right-5S	10C	"
	75,76	"	"	"	"	Left+25S Right-15S	"	"

NOTE: S = SIMPLE HINGED C = CONFORMAL

Figure 2 shows a comparison of the theoretical and experimental pressure distributions at the inboard wing station. The experimental pressure distribution has a slightly higher peak at the leading edge. At the rear an expected decambering effect takes place due to viscous effects. The outboard wing (Figure 3) shows good agreement of the peak pressures, but a slightly lower overall C_p-level on the upper surface. Boundary layer buildup again causes a decambering effect towards the trailing edge.

The next series of wind tunnel tests is scheduled to begin on June 25 in the NASA Ames 9 x 7 supersonic wind tunnel. These will be followed directly by low speed tests during the next week in the Ames 12-foot pressure wind tunnel.

CALC	KA SCHIPPERS 6-19-73	DATE

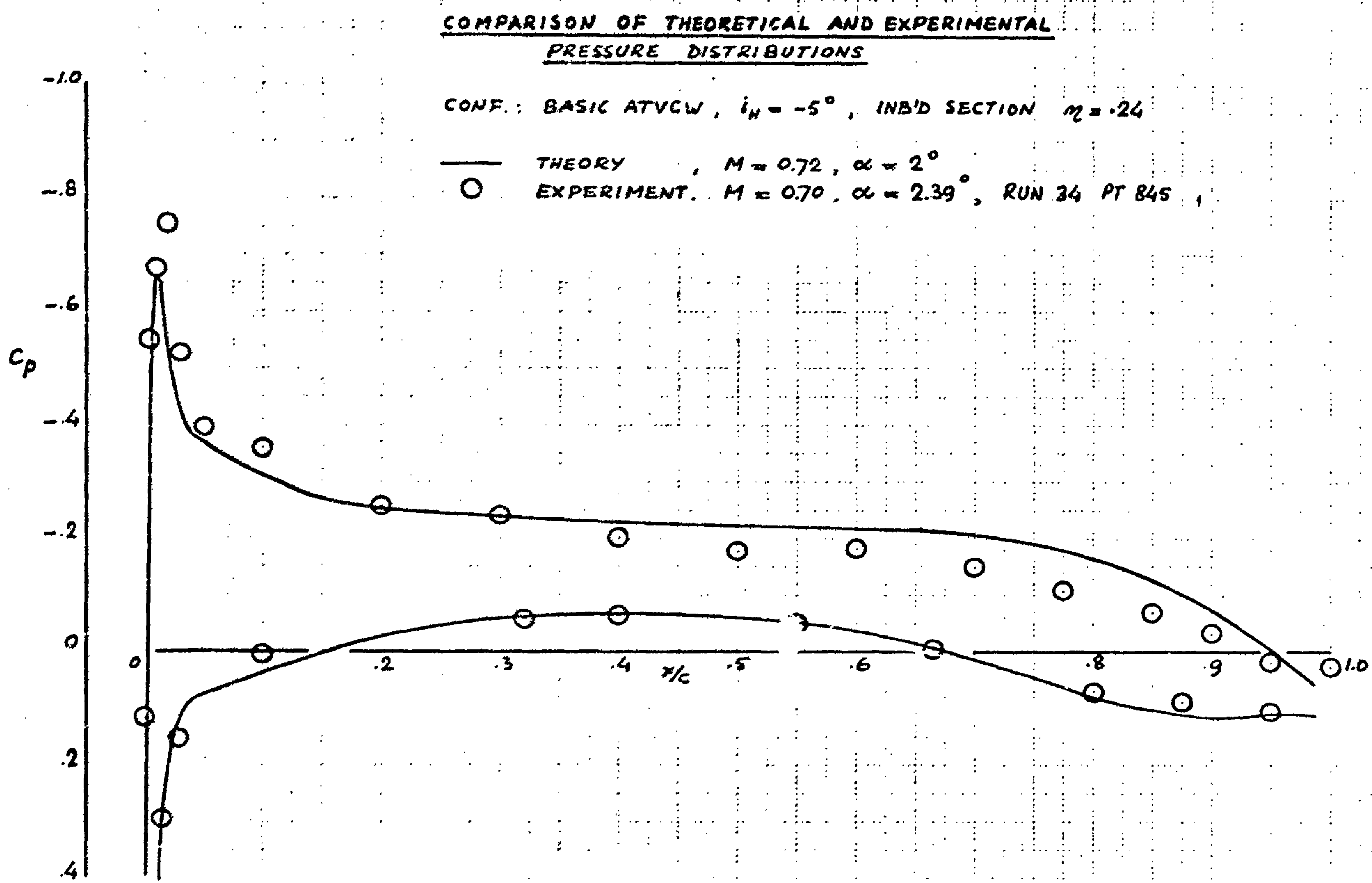
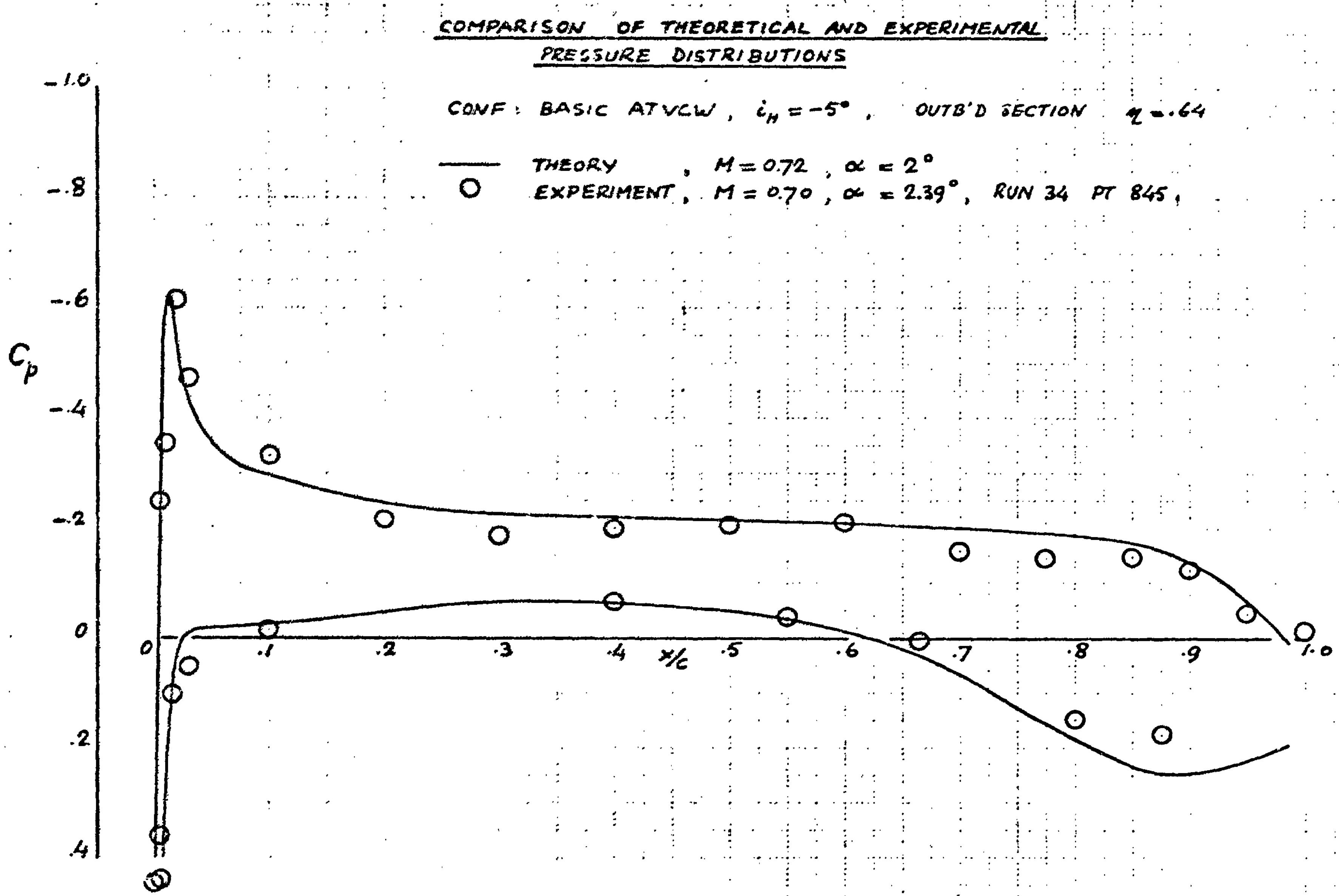


Fig 2



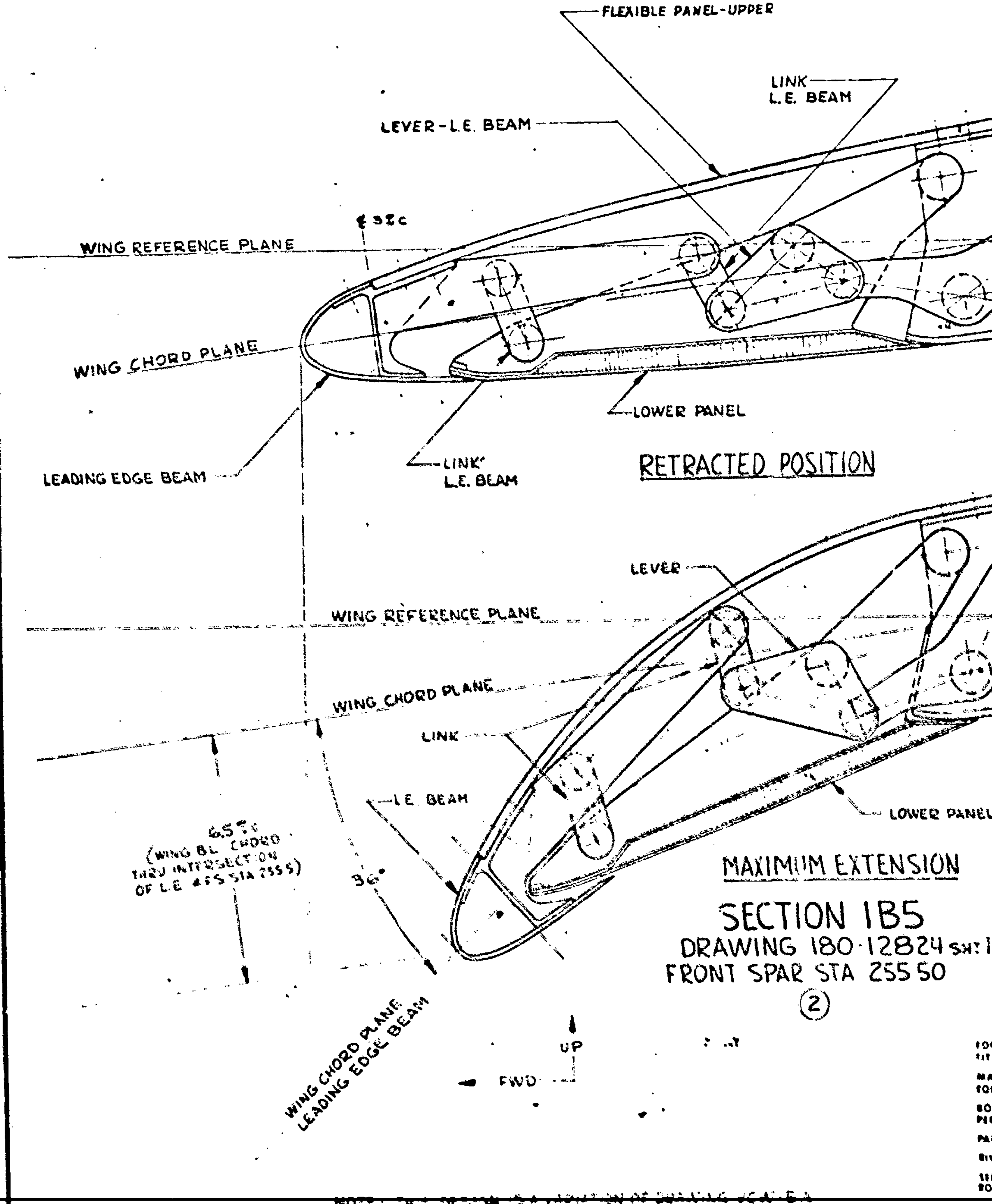
K.A.SCHIPPERS 6-19-73

Fig 3

STRUCTURAL DESIGN TRADES

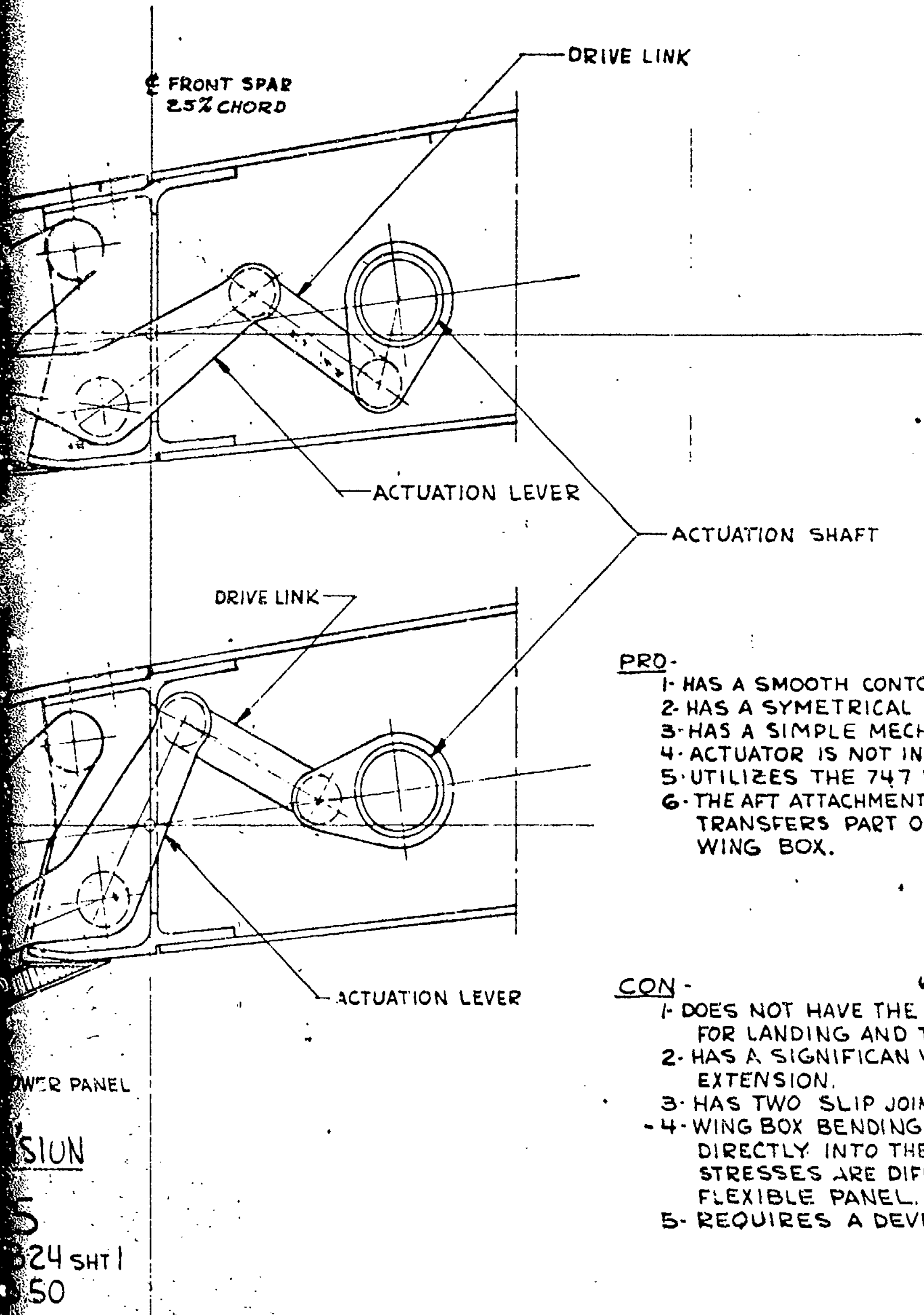
A number of variable camber leading edge concepts have been designed in an attempt to improve on the original concept described in Reference 1 and shown in Figure 4. The design trades included consideration of concepts to achieve greater deflections and no reduction in lifting surface area with deflection. Several of these concepts are shown in Figures 5 through 7. Figure 8 presents a comparison of the relative shapes and extensions of the leading edge flap systems for both the high speed maneuver and low speed takeoff and landing conditions. A simple hinge flap is included for comparison.

Reference 1: Ishimitsu, K. K.; "Mechanization and Utilization of Variable Camber in Fighter and Attack Airplanes"; Boeing Document D180-15377-1, January 1973.



SECTION 1B5
DRAWING 180-12824 SH 1
FRONT SPAR STA 255 50
(2)

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APP
A		REDRAWN TO INCREASE L.E. DEFLECTION	5/8/75	



PRO-

1- HAS A SMOOTH CONTOUR AT ALL ANGLES OF EXTENSION
2- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK-UP.
3- HAS A SIMPLE MECHANISM.
4- ACTUATOR IS NOT IN THE PRIMARY STRUCTURAL LOAD PA
5- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLO
6- THE AFT ATTACHMENT OF THE FLEXIBLE LEADING EDGE TRANSFERS PART OF THE AIR LOAD DIRECTLY INTO TH WING BOX.

CON -

1- DOES NOT HAVE THE REQUIRED LEADING EDGE EXTENS FOR LANDING AND TAKE-OFF. (FOR THIS PROGRAM)
2- HAS A SIGNIFICAN WING AREA REDUCTION AT MAXIMU EXTENSION.
3- HAS TWO SLIP JOINTS IN THE LOWER SURFACE.
4- WING BOX BENDING STRESSES ARE TRANSFERRED DIRECTLY INTO THE FLEXIBLE PANEL. (FLIGHT OPERAT STRESSES ARE DIFFICULT TO DETERMINE IN THE FLEXIBLE PANEL.
5- REQUIRES A DEVELOPMENT PROGRAM.

FORM, PUNCH, STRAIGHTEN & FIT METAL PARTS PER BAC 5300

MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 5005

BOLT & NUT INSTALLATION PER BAC 5009

PART MARKING PER BAC 5307

RIVET INSTL & SYM PER BAC 5004

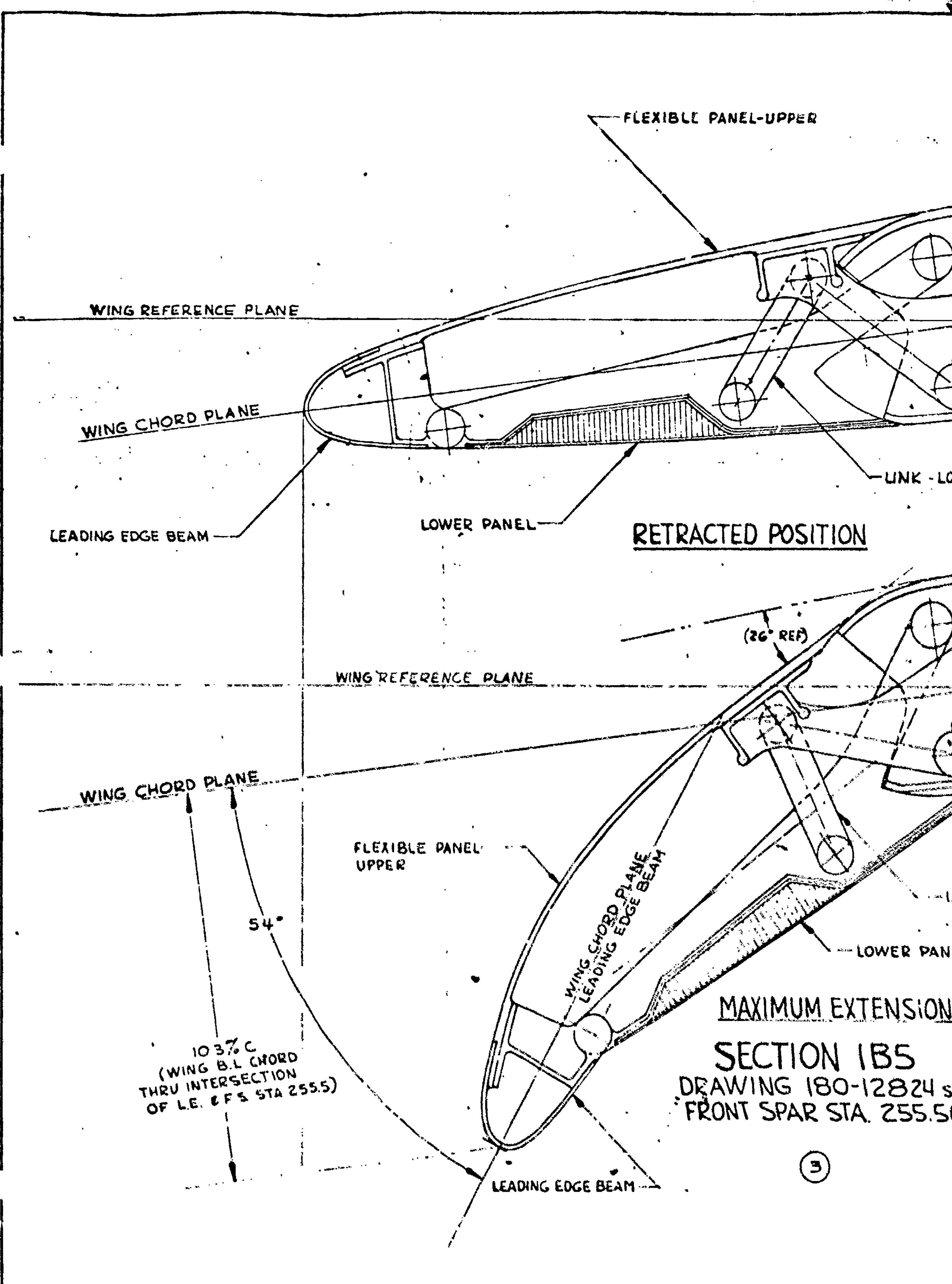
SEE BACD 2097 FOR SURFACE ROUGHNESS

FOR FINISH CODE SEE DOCUMENT D2-5000

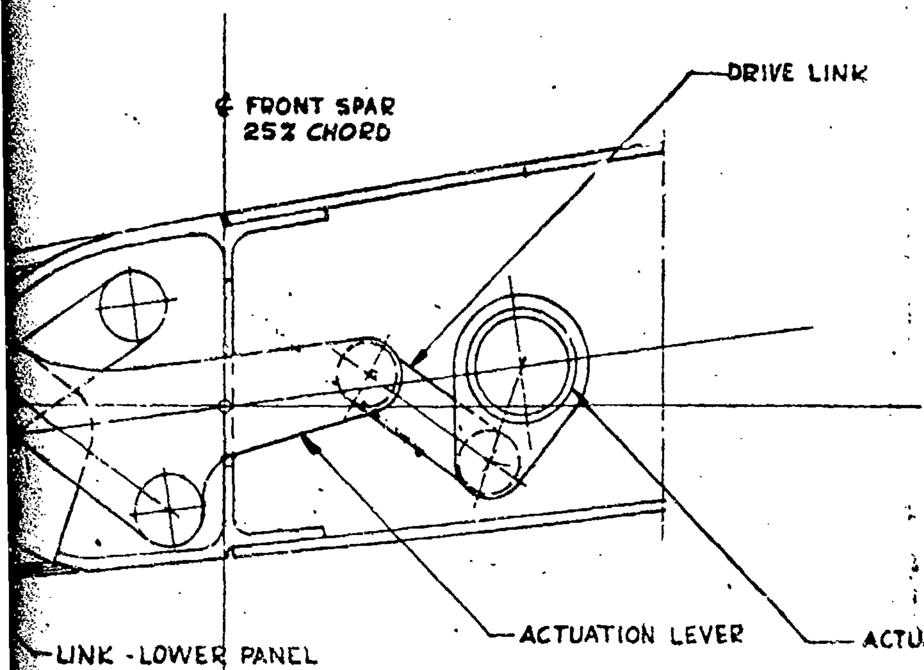
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ± DECIMALS ±
RIVET & BOLT EDGE MARGINS ±.05
SHEET METAL CORNER RADII ROUTED PARTS ONLY
INTERNAL 19/16
EXTERNAL 22 25/00
BEND RADII
.01 ON .01 & .06
.03 ON .09 & GREATER

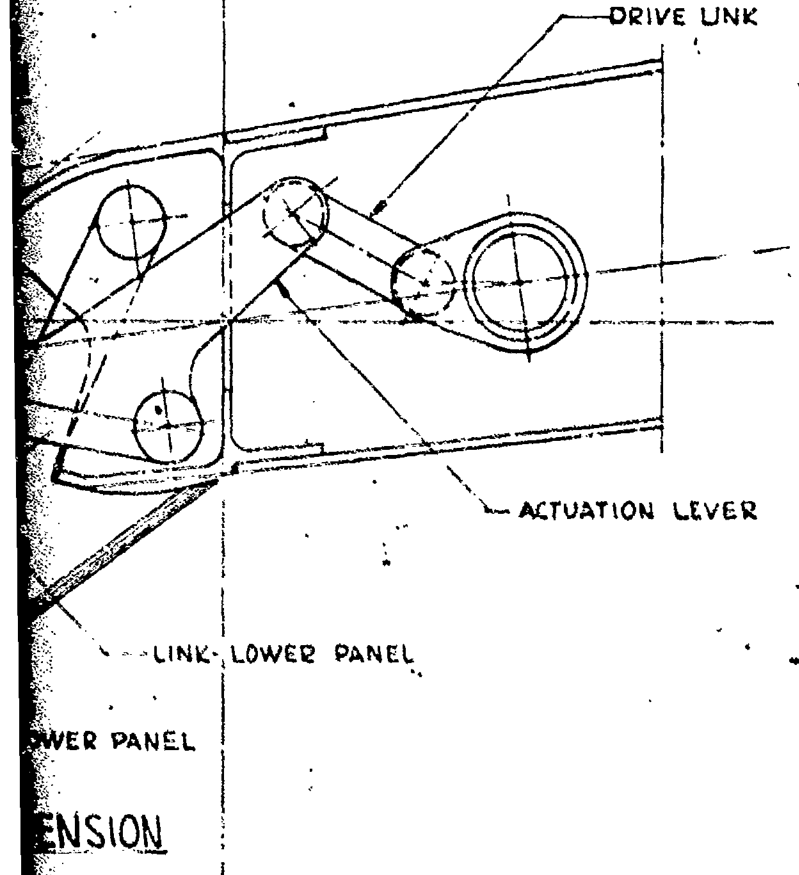
SEE SHEET 1 OR PL FOR LIST OF MATERIAL USAGE AND

USED ON	DRAWN M. McKAY	DATE	THE BOEING COMPANY
	CHECKED		
SECT NO	STRESS		LEADING EDGE FLAP VARIABLE CAMBER WING F-8 FLIGHT DEMONSTRAT
	ENGR		
CHG NO	GROUP		
	PROJ		CODE IDENT NO 81205 — SIZE D — 180-12824
GROUP ORG			SCALE FULL — SH 2


FLEXIBLE PANEL-UPPER
WING REFERENCE PLANE
WING CHORD PLANE
LEADING EDGE BEAM
LOWER PANEL
LINK - LO
RETRACTED POSITION
(26° REF)
WING REFERENCE PLANE
WING CHORD PLANE
FLEXIBLE PANEL UPPER
WING CHORD PLANE LEADING EDGE BEAM
54°
103% C (WING B.L CHORD THRU INTERSECTION OF L.E. & F.S. STA 255.5)
LEADING EDGE BEAM
LOWER PAN
MAXIMUM EXTENSION
SECTION IBS
DRAWING 180-12824 S
FRONT SPAR STA. 255.5
3

REVISIONS			
ZONE	LTR	DESCRIPTION	DATE





PRO -

1- HAS THE REQUIRED LEADING EDGE EXTENSION FO
LANDING AND TAKE-OFF.
2- HAS SMOOTH CONTOUR AT SMALL ANGLES OF EXTENSION. (HIGH SPEED MANEUVER)
3- DOES NOT TRANSFER THE WING BOX STRESSES DIRECTLY INTO THE FLEXIBLE PANEL.
4- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK
5- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLOGY
6- HAS A SIMPLE MECHANISM.
7- ACTUATOR IS NOT IN THE PRIMARY STRUCTURAL LOAD PATH.

CON -

1- HAS A FLAT SPOT IN THE CONTOUR AT HIGH ANGLES OF EXTENSION. (LANDING AND TAKE-OFF.)
2- REQUIRES A DEVELOPMENT PROGRAM.
3- HAS TWO SLIP JOINTS. (ONE UPPER, ONE LOWER)
4- UTILIZES THE FLEXIBLE SKIN AS A PUSH ROD IN THE MECHANISM TO LOCATE THE LEADING EDGE BEAM.
5- AT LARGE LEADING EDGE DEFLECTIONS THE AIRF[illegible] RADIUS ON THE UPPER SURFACE IS THE SAME AS SIMPLE HINGED LEADING EDGE.

WER PANEL

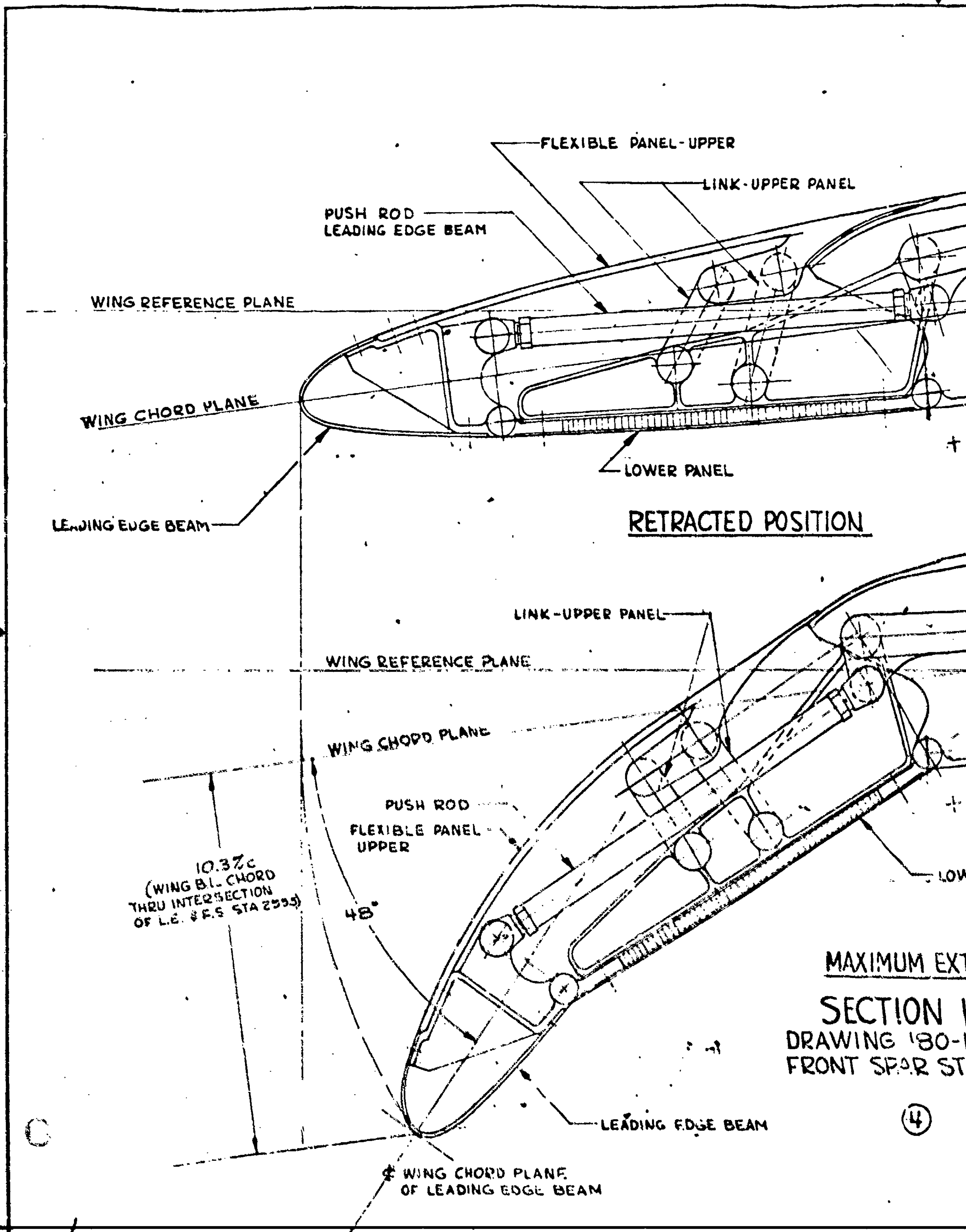
ENSION

35
2824 SHT 1
255.50

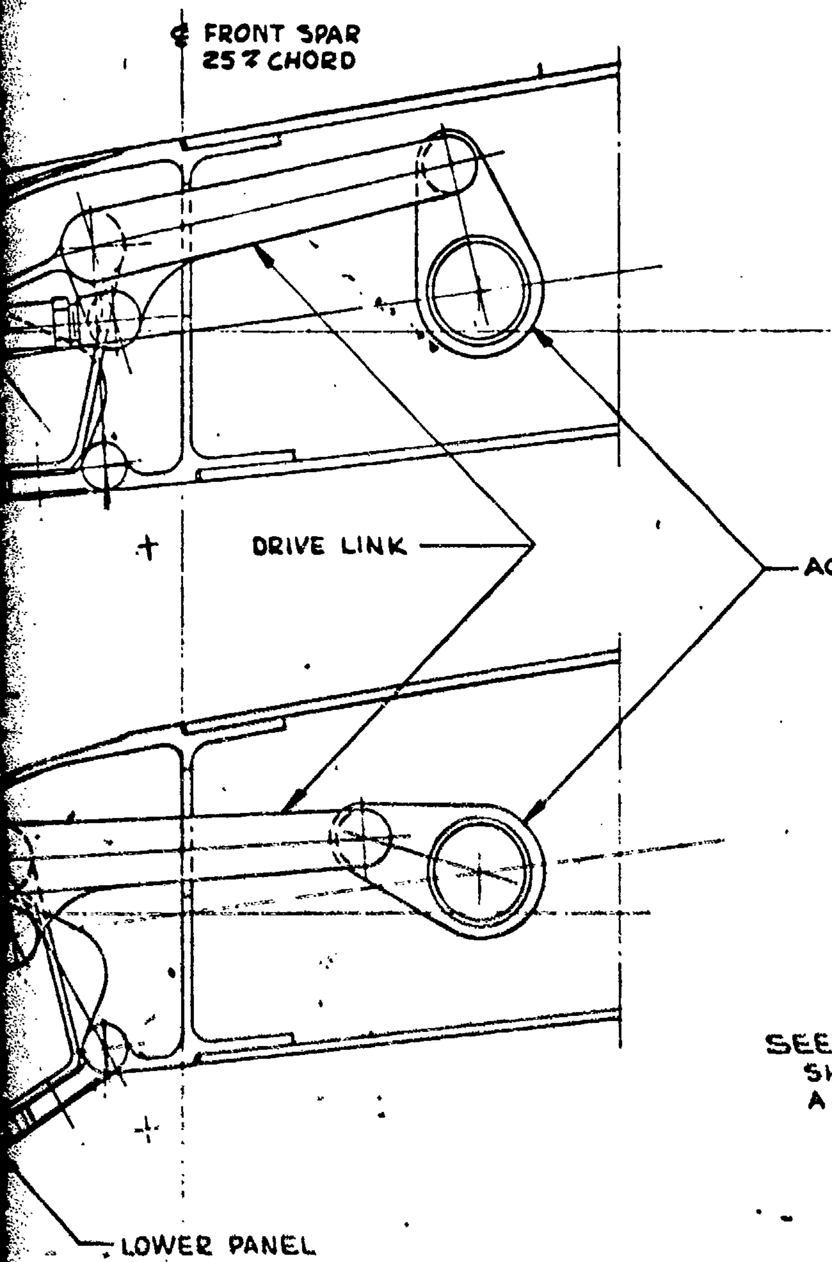
SEE SHEET 1 FOR LIST OF MATERIAL AND NOTES

USED ON	CONTR / DR M. M. Kinney 5-11-73 / CHK / STRUCT / ENGR 5-?-73 / GP / PROJ	THE BOEING CO. SEATTLE, WASHINGTON
SECT NO.		LEADING EDGE FLAP VARIABLE CAMBER WING F-8 FLIGHT DEMONSTRAT
CHG NO.		SIZE D / CODE IDENT NO 81205 / 180-1282
		SCALE FULL / 3

Fig 5


FLEXIBLE PANEL-UPPER
LINK-UPPER PANEL
PUSH ROD
LEADING EDGE BEAM
WING REFERENCE PLANE
WING CHORD PLANE
LOWER PANEL
LEADING EDGE BEAM
RETRACTED POSITION
LINK-UPPER PANEL
WING REFERENCE PLANE
WING CHORD PLANE
PUSH ROD
FLEXIBLE PANEL UPPER
10.3%c
(WING B.L. CHORD
THRU INTERSECTION
OF L.E. & F.S. STA 2555)
48°
MAXIMUM EXT
SECTION
DRAWING 180-
FRONT SPAR ST
4
LEADING EDGE BEAM
℄ WING CHORD PLANE
OF LEADING EDGE BEAM

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP



SEE SHT 5 FOR NOTES
SHT 4 & SHT 5 ARE THE SAME EXCEPT FOR A SMALL CHANGE IN LEADING EDGE ANGLE.

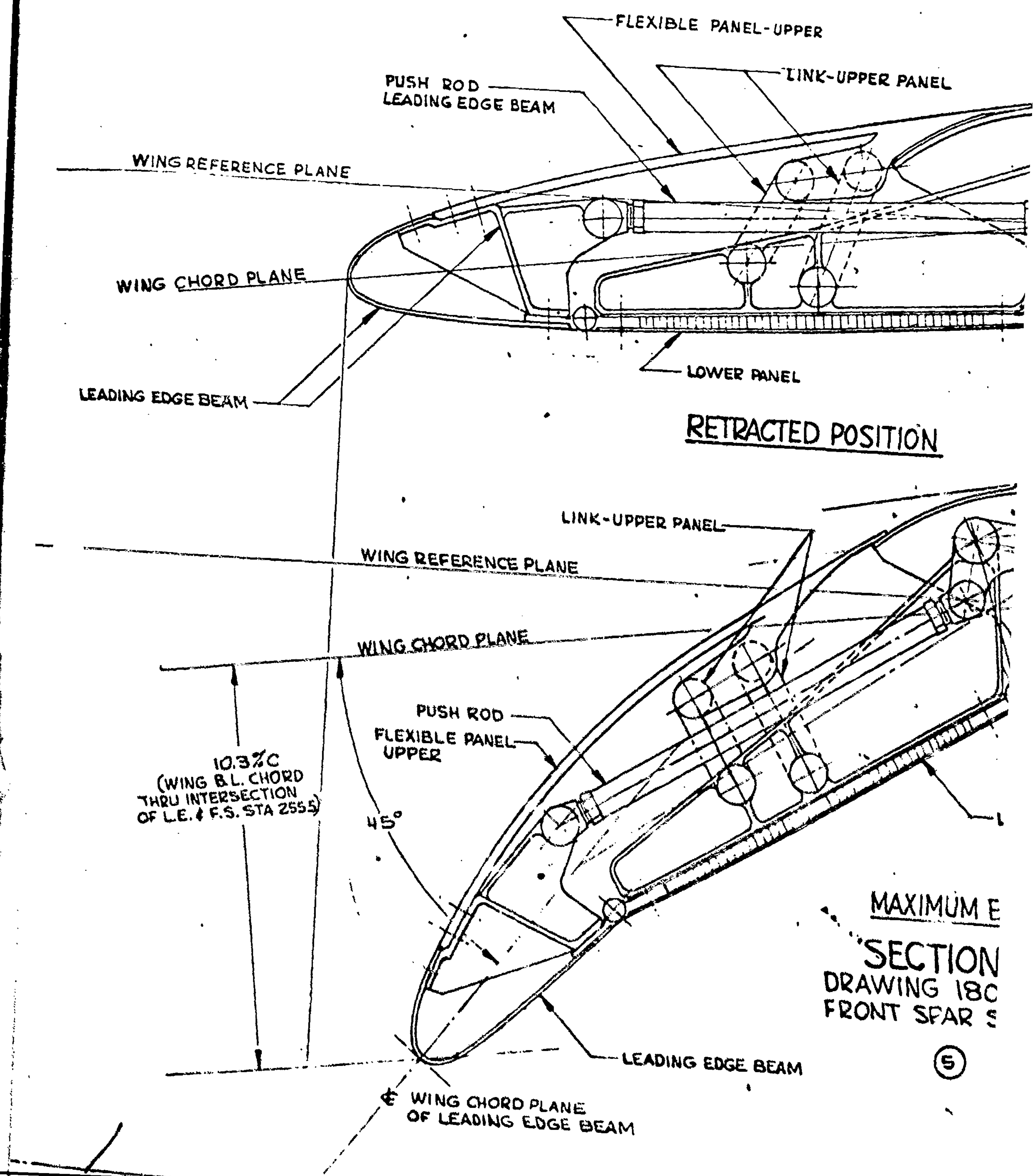
IMUM EXTENSION

TION 1B5
NG 180-12824 SHT 1
SPAR STA 255.50

(4)

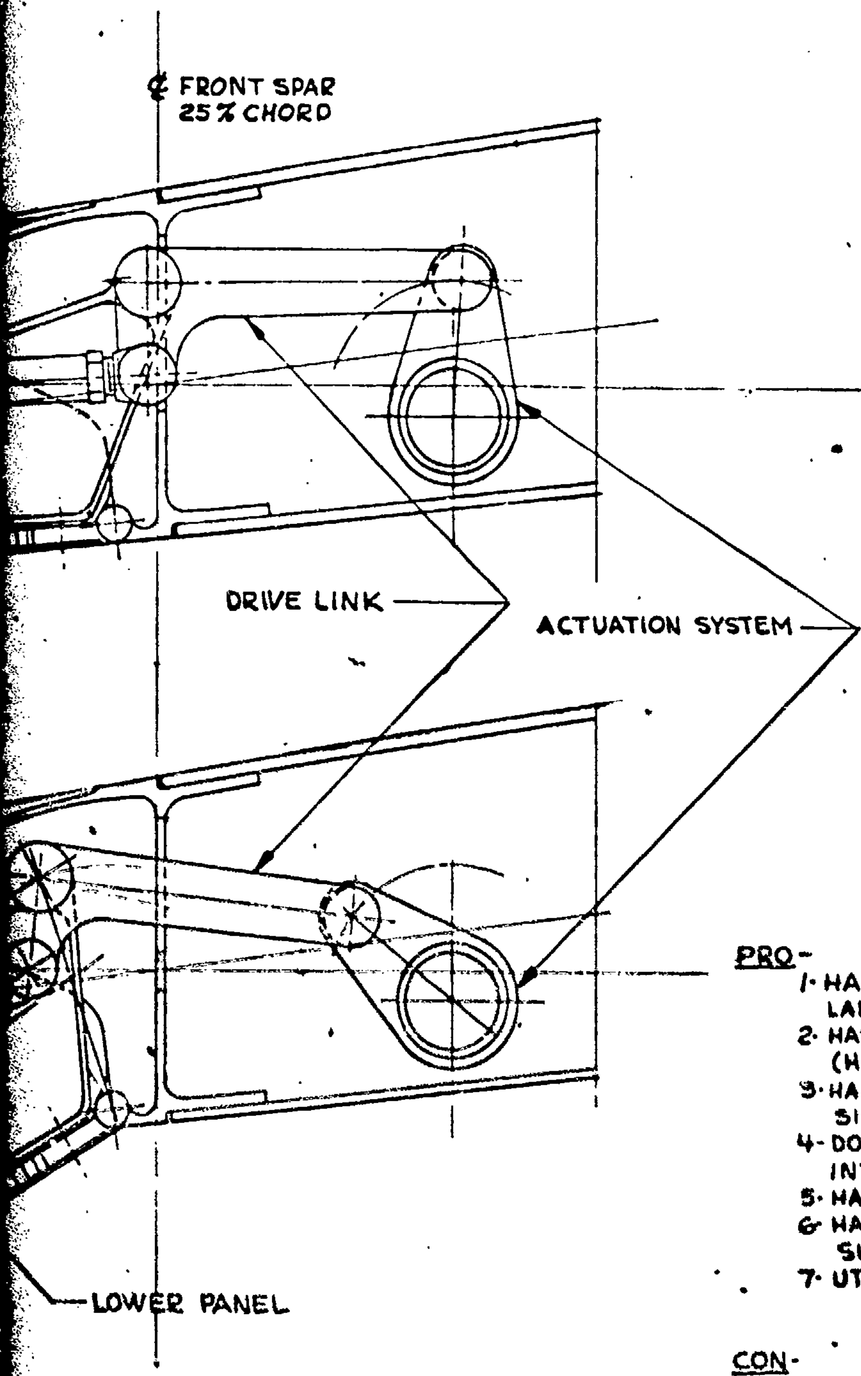
SEE SHEET 1 FOR LIST OF MATERIAL AND NOTES

USED ON			THE BOEING COM
	DR M.M.KINNEY	5-18-73	SEATTLE, WASHINGTON
	CHK		LEADING EDGE FLAP
SECT NO	STRUCT		VARIABLE CAMBER WING
	ENGR	5-18-73	F-8 FLIGHT DEMONSTRAT
CHG NO	GR	PROJ	SIZE CODE 180-1282



FLEXIBLE PANEL-UPPER
LINK-UPPER PANEL
PUSH ROD
LEADING EDGE BEAM
WING REFERENCE PLANE
WING CHORD PLANE
LOWER PANEL
LEADING EDGE BEAM
RETRACTED POSITION
LINK-UPPER PANEL
WING REFERENCE PLANE
WING CHORD PLANE
PUSH ROD
FLEXIBLE PANEL
UPPER
10.3%C
(WING B.L. CHORD
THRU INTERSECTION
OF L.E. & F.S. STA 2555)
45°
MAXIMUM E
SECTION
DRAWING 18C
FRONT SPAR S
LEADING EDGE BEAM
5
℄ WING CHORD PLANE
OF LEADING EDGE BEAM

REVISIONS



PRO-

1- HAS THE REQUIRED LEADING EDGE EXTENSION FOR LANDING AND TAKE-OFF.
2- HAS A SMOOTH CONTOUR AT SMALL ANGLES OF EXTENSION. (HIGH SPEED MANEUVER)
3- HAS A MINIMUM WING AREA REDUCTION. (SAME AS A SIMPLE HINGE LEADING EDGE)
4- DOES NOT TRANSFER THE WING BOX STRESSES DIRECTLY INTO THE FLEXIBLE PANEL.
5- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK-UP.
6- HAS A MINIMUM NUMBER OF SLIP JOINTS (ONE IN UPPER SURFACE)
7- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLOGY.

CON-

1- HAS A FLAT SPOT IN THE CONTOUR AT HIGH ANGLES OF EXTENSION. (LANDING AND TAKE-OFF)
2- DIFFICULT TO FABRICATE AND ADJUST
3- MECHANISM IS MORE COMPLICATED THAN BASELINE DESIGN.
4- REQUIRES A DEVELOPMENT PROGRAM.

UM EXTENSION

TION 1B5

180-12824 SHT 1

PAR STA. 255.50

5

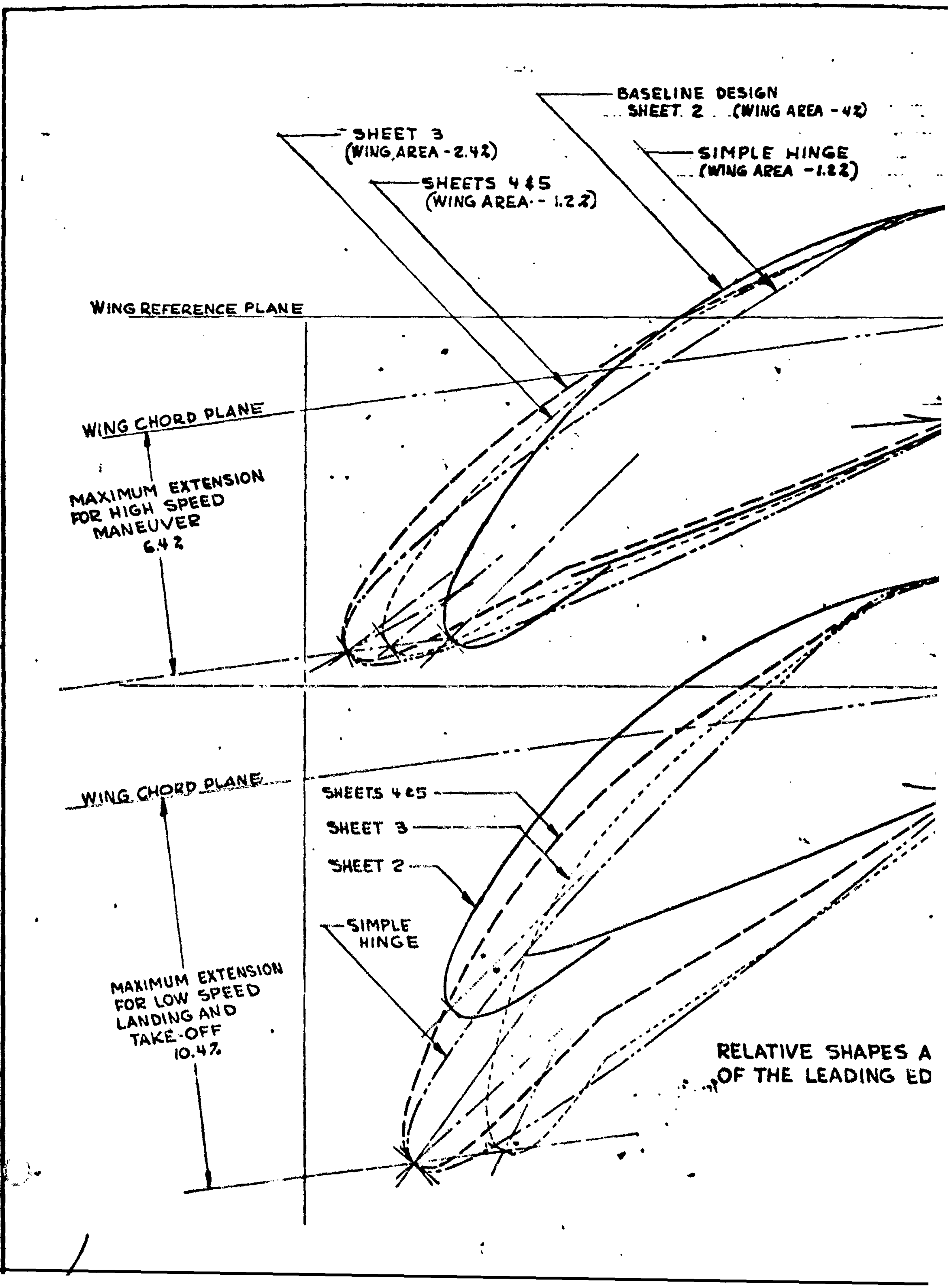
THE BOEING COMPANY
SEATTLE WASHINGTON

LEADING EDGE FLAP
VARIABLE CAMBER WING
F-8 FLIGHT DEMONSTRATOR

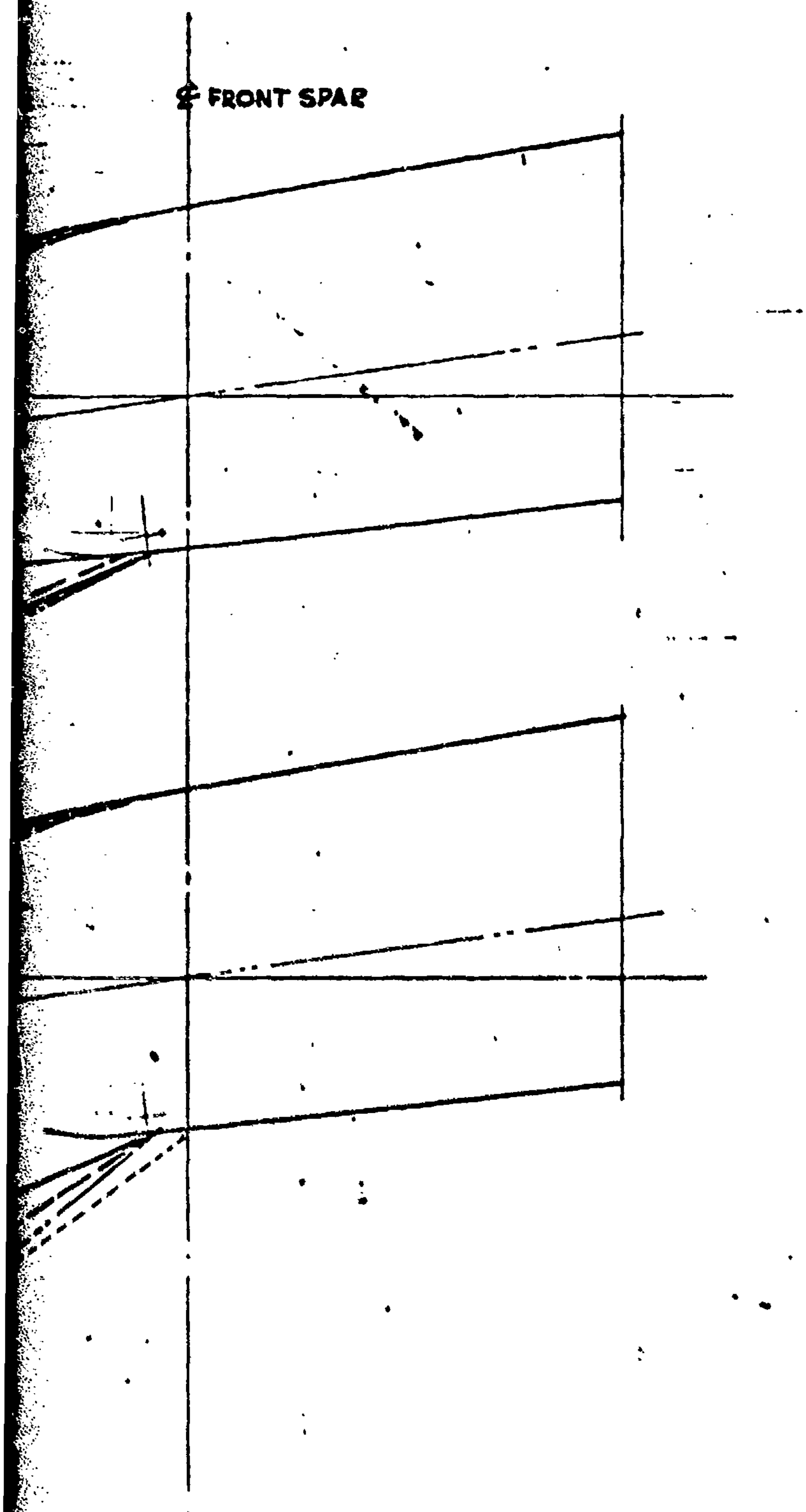
M McKINNEY 5-21-73

5-23-73

D 81205 180-12824


BASELINE DESIGN
SHEET 2 (WING AREA - 4%)
SHEET 3
(WING AREA - 2.4%)
SIMPLE HINGE
(WING AREA - 1.2%)
SHEETS 4 & 5
(WING AREA - 1.2%)
WING REFERENCE PLANE
WING CHORD PLANE
MAXIMUM EXTENSION
FOR HIGH SPEED
MANEUVER
6.4%
WING CHORD PLANE
SHEETS 4 & 5
SHEET 3
SHEET 2
SIMPLE
HINGE
MAXIMUM EXTENSION
FOR LOW SPEED
LANDING AND
TAKE-OFF
10.4%
RELATIVE SHAPES A
OF THE LEADING ED

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROV



S AND EXTENSIONS
EDGE FLAP SYSTEMS

SEE SHEET 1 FOR LIST OF MATERIAL AND NOTES

USED ON	CONTR		THE BOEING COMP
	DR M. McKINNEY	5-25-79	SEATTLE, WASHINGTON
	CHK		LEADING EDGE FLAP
SECT NO.	STRUCT		VARIABLE CAMBER WING
	ENGR M. McKinney	5/25/79	F8 FLIGHT DEMONSTRATO
CHG NO			
	GR	PROJ	SIZE D · CODE IDENT NO · 180-12824

STRUCTURES

The main wing structural box has been sized and weighed. Leading edges based on the original design concept have also been sized.

Input data for the flutter analysis has been generated and results will be available during the coming month.

Potential flow theoretical pressures have been computed for the basic wing and with the leading edges drooped 30 degrees. They confirm the assumption that leading edge upper surface pressures approach a vacuum at buffet lift coefficients.

3.0 NEXT REPORT PERIOD PROJECTION

During the next report period the principal effort will involve conduct of the wind tunnel tests at NASA Ames Research Laboratory and analysis of the data from the initial series of tests.

The structural design trades will continue and the loads, stress, flutter and weights analyses will near completion.

Safety and failure mode analyses of the control systems will be conducted.

4.0 EXPENDITURE STATUS

As of mid-June 1973, the program expenditures are within the revised forecast.